July, 2012

2012 International SWAT Conference & Workshops

Hydrological Modelling of Kosi and Gandak Basins using SWAT Model

S. Dutta, Pritam Biswas, Sangita Devi, Suresh A Karth and Bimlesh kumar,

Ganga River Basin Management Plan

INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

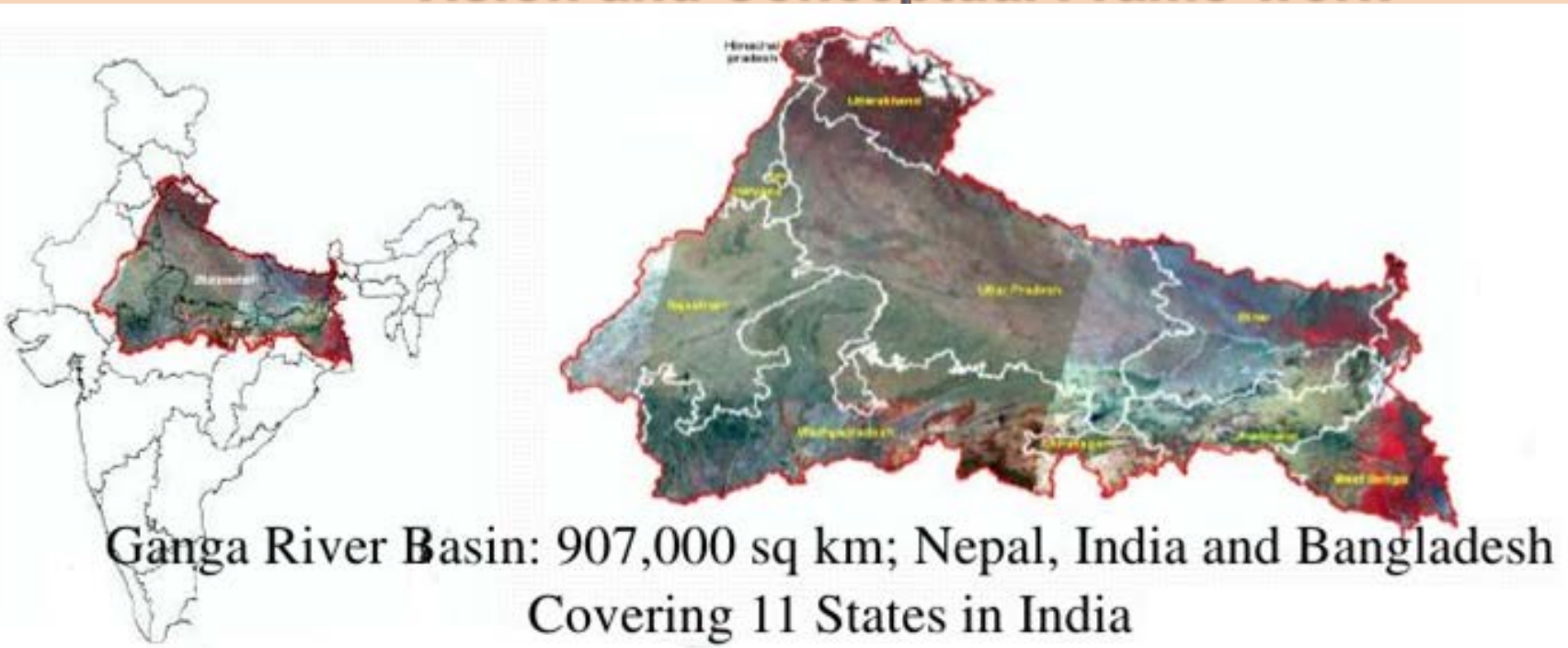
GUWAHATI-781039

ASSAM, INDIA

Ganga River Basin Environment Management Plan

GRBEMP

Vision and Conceptual Frame-work



Ganga River Basin: 907,000 sq km; Nepal, India and Bangladesh
Covering 11 States in India

IIT Bombay | IIT Delhi | IIT Guwahati | IIT Kanpur | IIT Kharagpur | IIT Madras | IIT Roorkee

The Action Plan

Comprehensive co-ordinated studies would have to be conducted on the following aspects of Ganga:

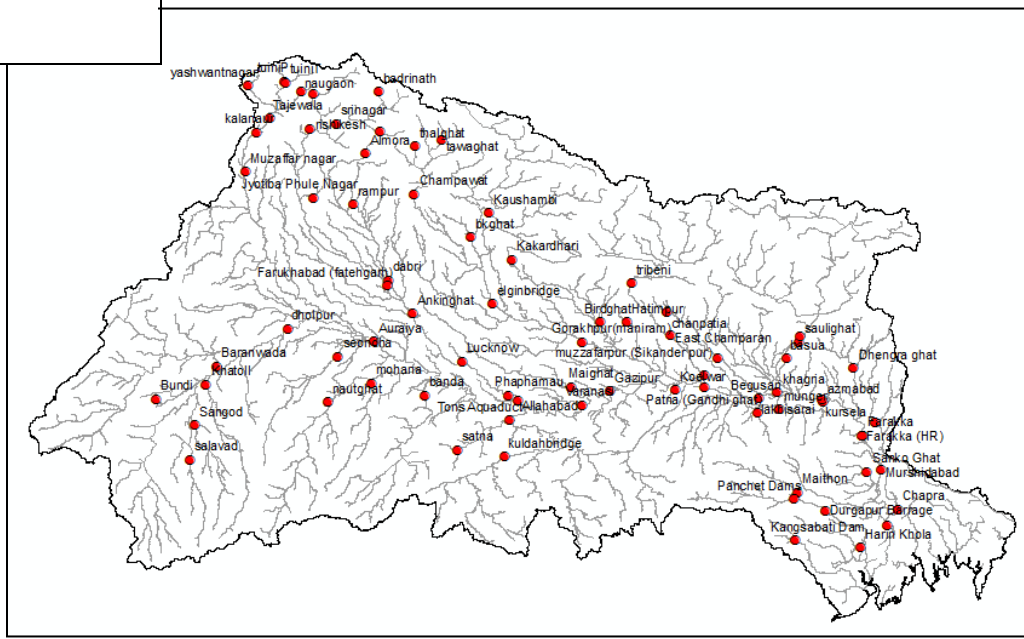
- **The sources and nature of the pollution.**
- **A more rational plan for the use of the resources of the Ganga for agriculture, animal husbandry, fisheries, forests, etc.**
- **The possible revival of the inland water transport facilities of the Ganga, together with the tributaries and distributaries.**

IITs help in effort to clean up Ganga :

- To help in preparing the basin-scale plan to clean the Ganga River and its tributaries
- The joint committee comprising representatives from the IITs at Bombay, Delhi, Guwahati, Kanpur, Kharagpur, Madras and Roorkee under ministry of environment and forests (MoEF).IIT-Kanpur monitors progress of the plan and help set up a project management board and project implementation and coordination committee.

Ganga River Basin Boundary with CWC Gauge stations

CWC gauging stations



OBJECTIVES

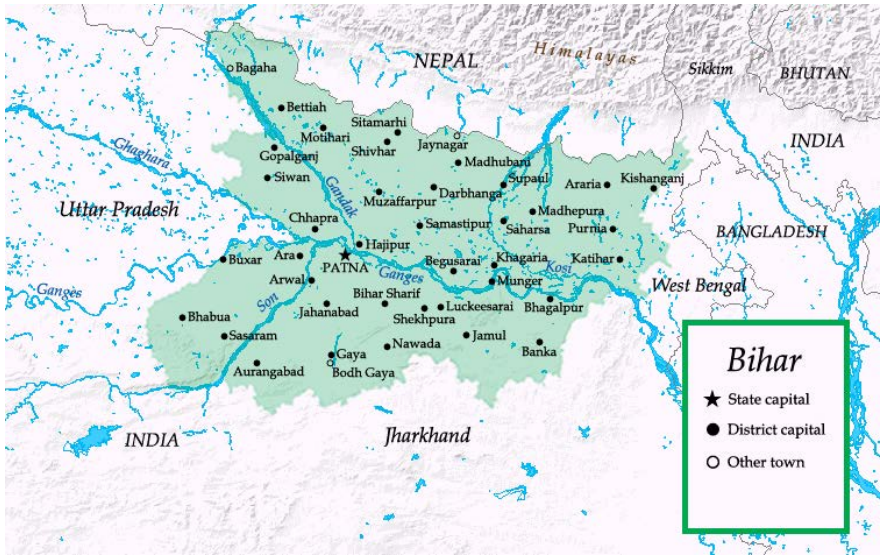
- To obtain the variation of water availability of these Ganga Tributaries for both monthly and annual scales
- To evaluate the model's performance in predicting low month flow (January to April) which are essential for e-flow analysis
- To obtain the critical calibration parameters of SWAT model for predicting the hydrological response at the scales.

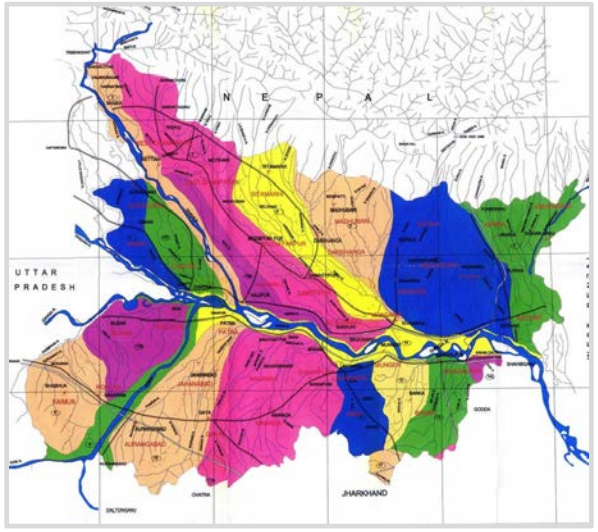
Study Basins

- Patna to Farakka

- Main River Basin Comes under "IIT - Guwahati Study Area"

- Gandak Basin
- Burhi-Gandak Basin
- Kosi Basin
- Badua Basin
- Bilasi Chandan
- Harohar (Kiul) Basin
- Kamla balan Basin
- Punpun Basin

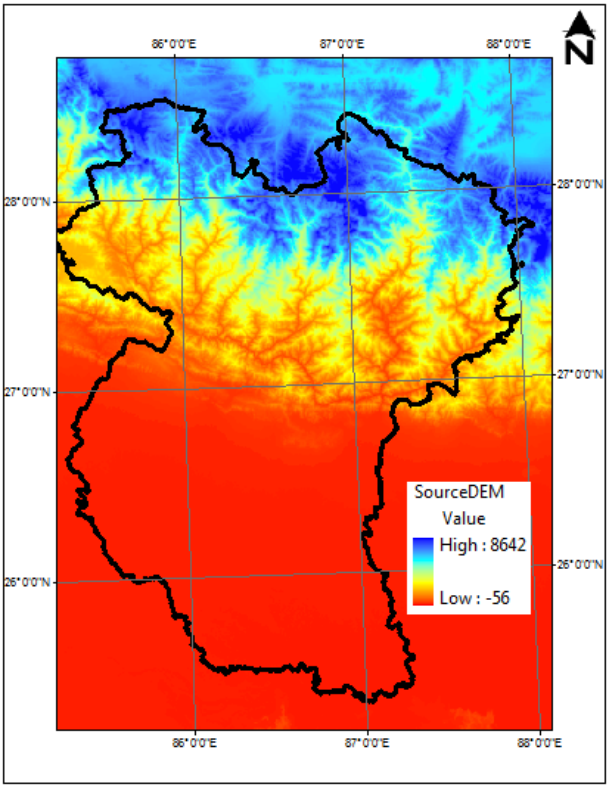




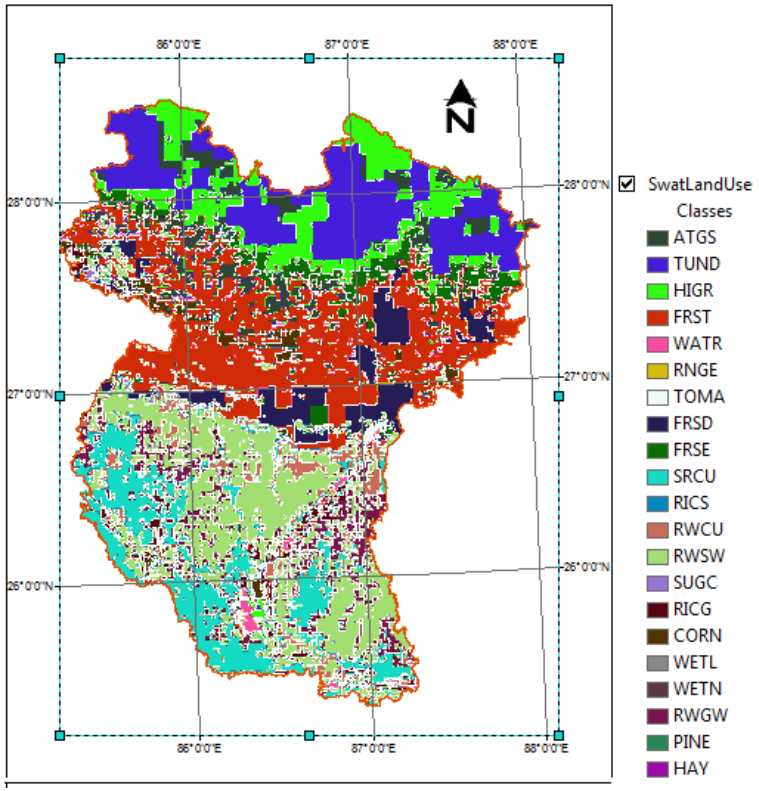
Major River Basins of Bihar

Geospatial dataset KOSI RIVER BASIN

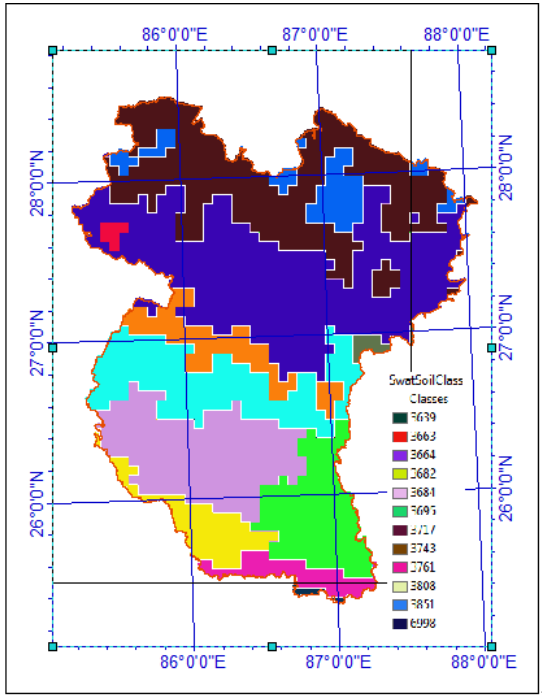
Topographic Map



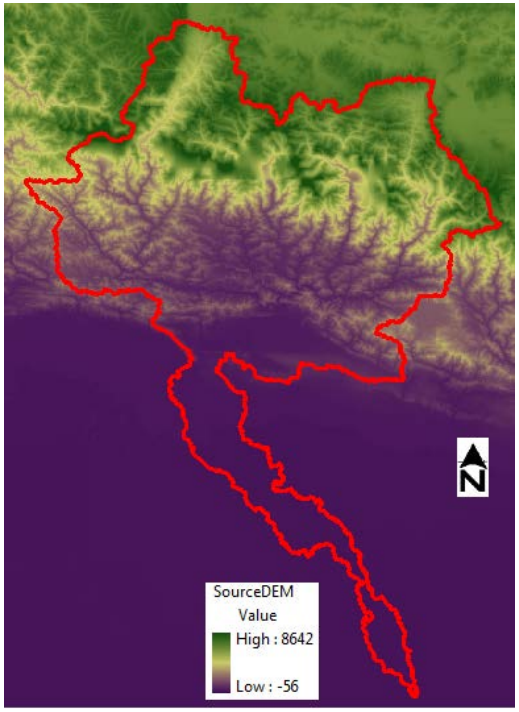
Land-Use /land cover Map



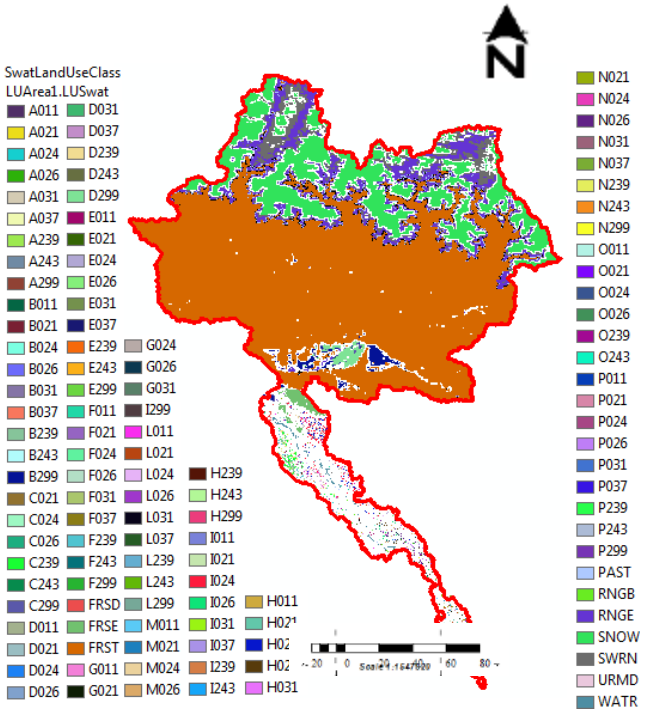
Soil Map



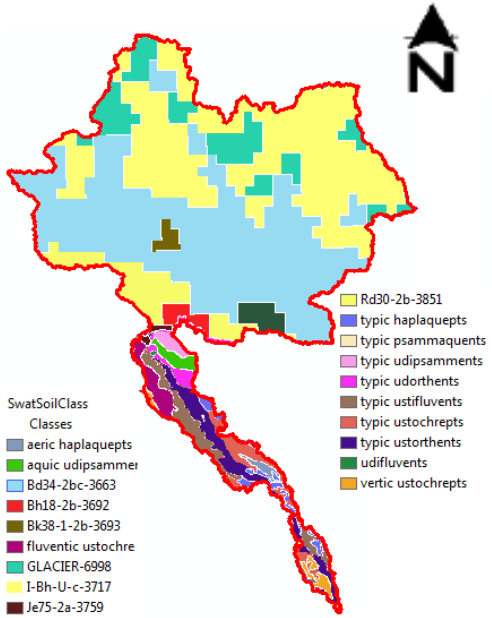
GANDAK RIVER BASIN



Topographic Map

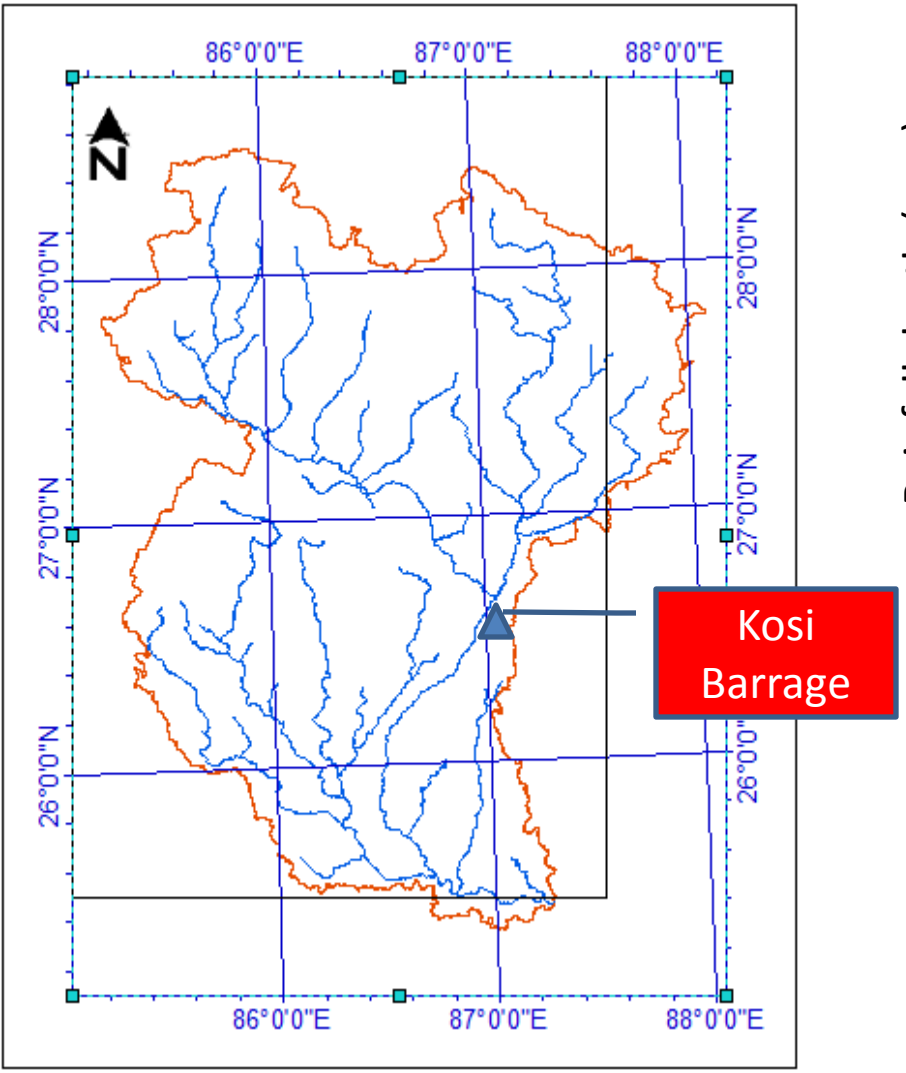


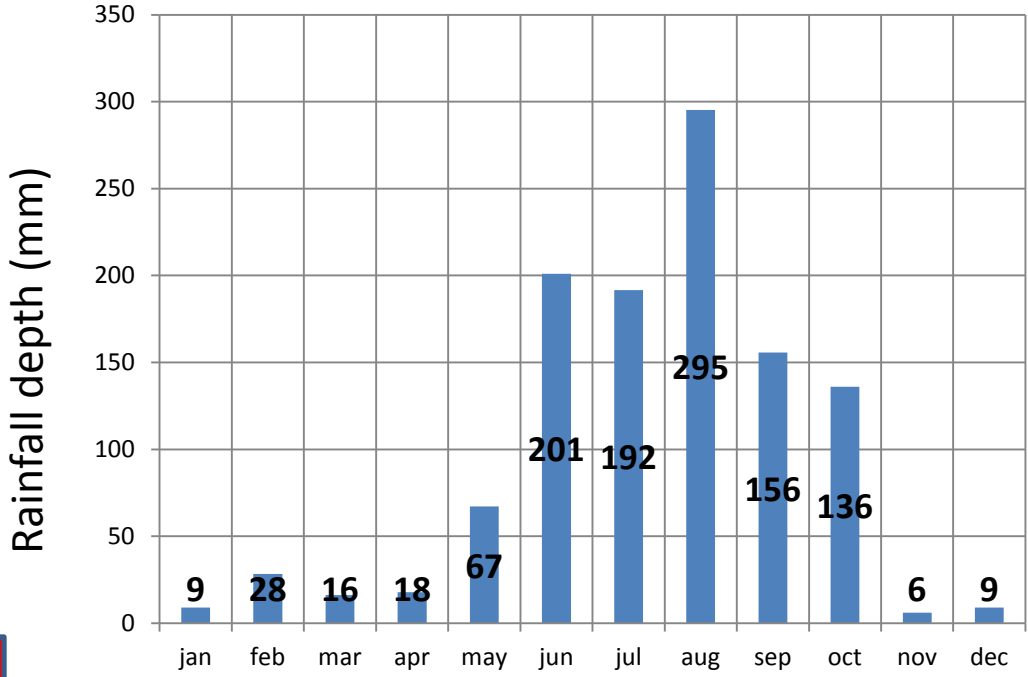
Land use/land cover



Soil Map

Major hydroprojects and rainfall variation





Hydro-Meteorological Observation

Monsoon period : May to October with peak rainfall in August month

Lean flow period : Jan to April dominated by GW (long delay flow) and Snow melting runoff

Flow increasing Period : May to August, dominated by SW and GW

Flow Descending period: August – December, dominated by GW (short delay flow) and SW period

Methodology

- Calibration Parameters identified for this study are
  - Lateral Flow Travel Time
  - Groundwater Delay
  - Alpha Base Factor
  - Slope length for lateral subsurface flow
  - Crack Flow

Model calibration for Kosi basin using Satellite altimetry observation data (2003 to 2006)

Model validation for Kosi Basin for both low month flow and annual water yield (1961-1991)

Model validation for Gandak basin for annual yield variation

	Observed Discharge Data Available
Kosi	Monthly discharge from 1961 – 1991 (at Saptakosi) by Bihar State Irrigation Commission, 1994 Daily discharge from 2003 – 2006 by Altimetry Satellite
Gandak	Annual from1974 – 1992 (at Lalganj), Annual from 1961 – 1992 (at Valmikinagar)

Status of Data (Hydrological modeling)*

Data	Availability	Source	Nature of data	Format of data	Data required
Digital Elevation Model (DEM)	Ganga River Basin	SRTM	Resolution 90x90m grid	Raster	-
Stream	Ganga River Basin	WRM Gr., IITD	Vector data as line.	Shape files	-
Land Use	Ganga River Basin	IWMI NRSC	500x500 m resolution grid 56x56 m resolution grid and 1:2,50,000 scale	Raster	-
Soil	Ganga River Basin	FAO NBSSLUP	7x7 km resolution grid and 1:5 m scale 1:2,50,000 scale	Raster	-
Irrigation Projects (Total # 237; Existing -186, Planned- 52)	Ganga River Basin	National Dam Register	Point locations	Vector data in point shape file	Dams (#33) Operation policies

* Data prepared by GRBEMP group of IIT Delhi and IIT Madras

Status of Data (Hydrological modeling- Surface water) *contd..*

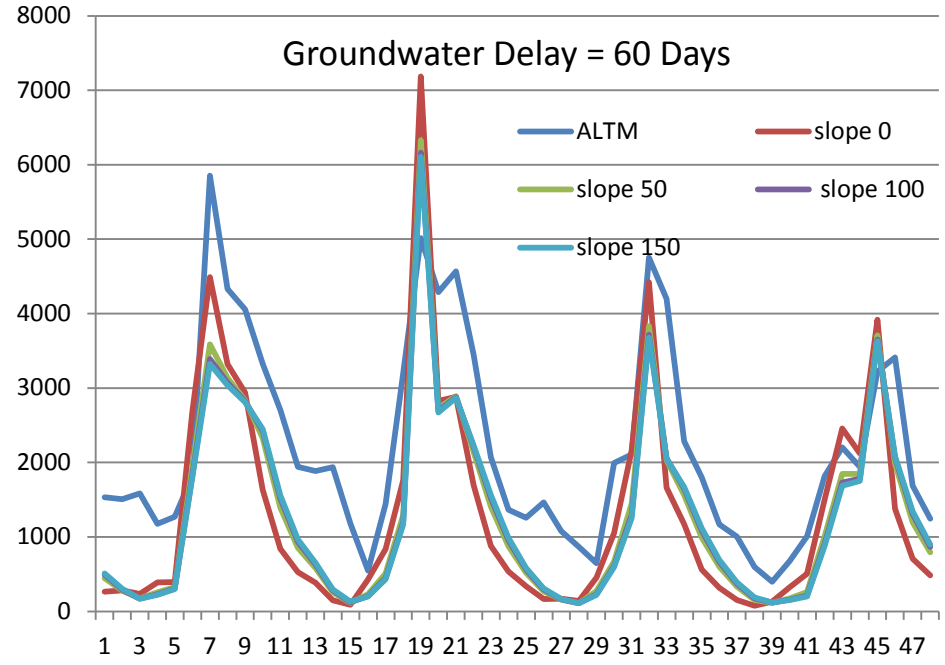
Data	Availability	Source	Nature of data	Format of data	Data required
Canal Network	Ganga River Basin	GIS Server, IITD	Location & type of canal	Vector data in point shape files	Attributes
Discharge, water level, water quality & sediment load	Outflow and Inflow Yield, Flow Duration Curve	CWC	Partial	Hard Copy	All Stations Daily Discharge Data
Aphrodite data	Ganga River Basin	GIS Server, IITD	Temporal rainfall data 0.25° (1961-2006)	Vector data in point shape file	-
Princeton data	Ganga River Basin	GIS Server, IITD	Temporal data of Relative Humidity, Wind Speed, Temperature & Solar radiation (1° gridded data; 1948-2006)	Vector data in point shape files	-
IMD data	Ganga River Basin	IMD	Temporal data of : Rainfall & Temperature data (0.5° gridded data; 1969 – 2005)	Vector data in point shape file	-

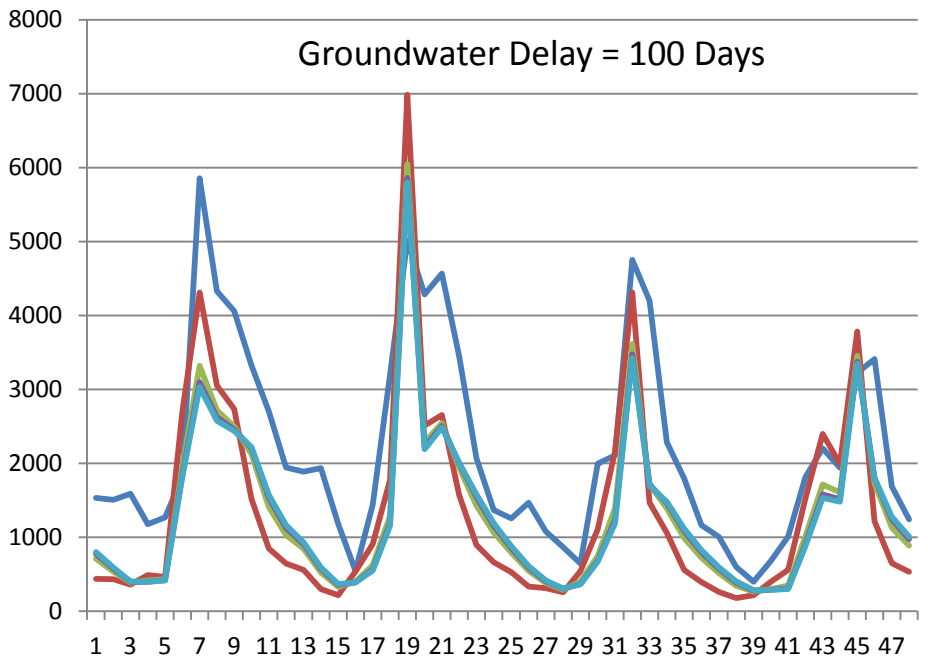
* Data prepared by GRBEMP group of IIT Delhi and IIT Madras

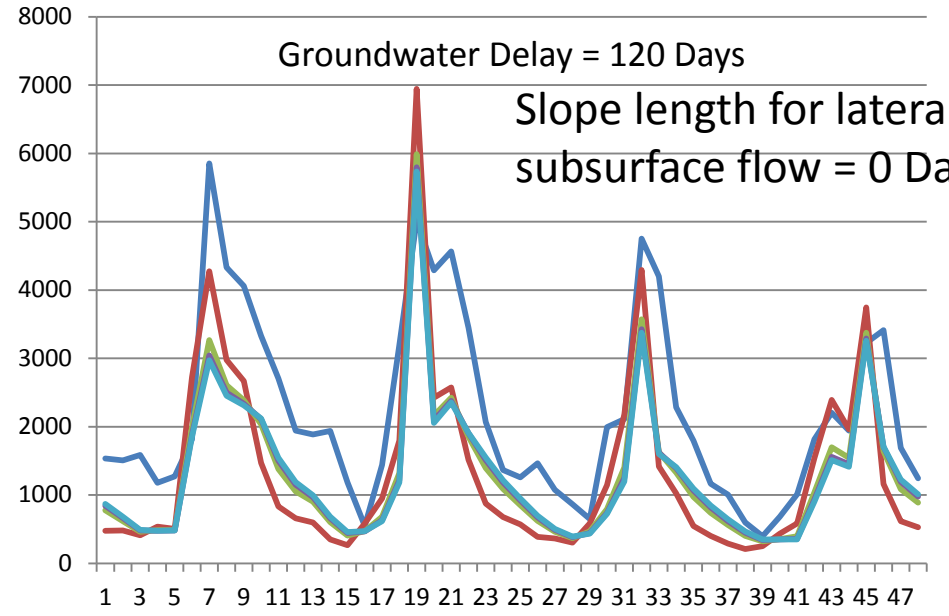
Model Calibration Parameters

S. No.	Parameters	Range	Default	Values Taken
1	Lateral flow travel time	0 – 180 days	0	0, 15, 30
2	Groundwater Delay	0 – 500 days	31	60, 100, 120, 150
3	Slope length for lateral subsurface flow	0 – 150 m	0	0, 50, 100, 150
4	Alpha Base Factor	0 - 1	0.048	0.048, 0.3, 0.6
5	Crack Flow	Active - Inactive	Inactive	Both

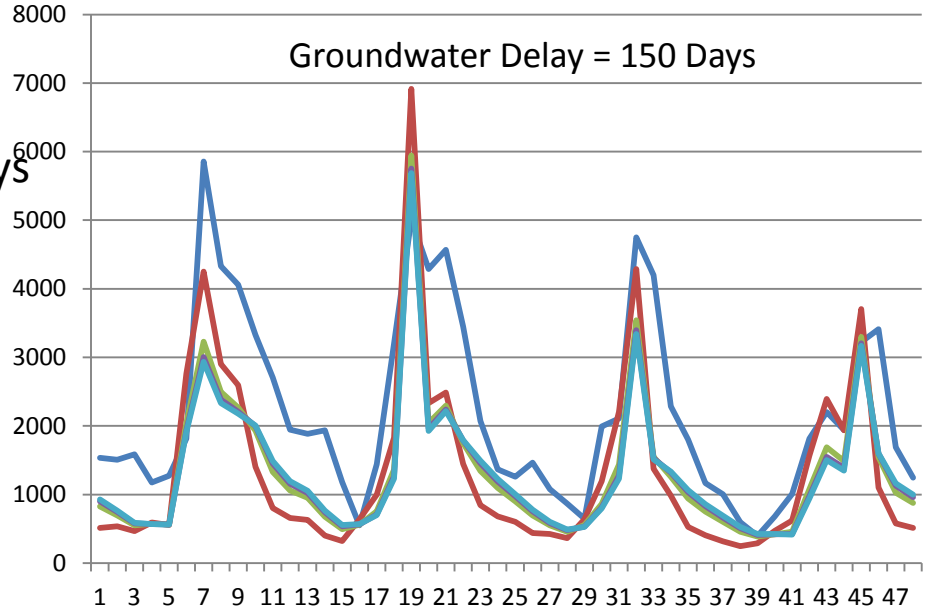
Effect of Groundwater Delay parameter







Slope length for lateral subsurface flow = 0 Days



Correlation Coefficient for Different Parameter Combinations

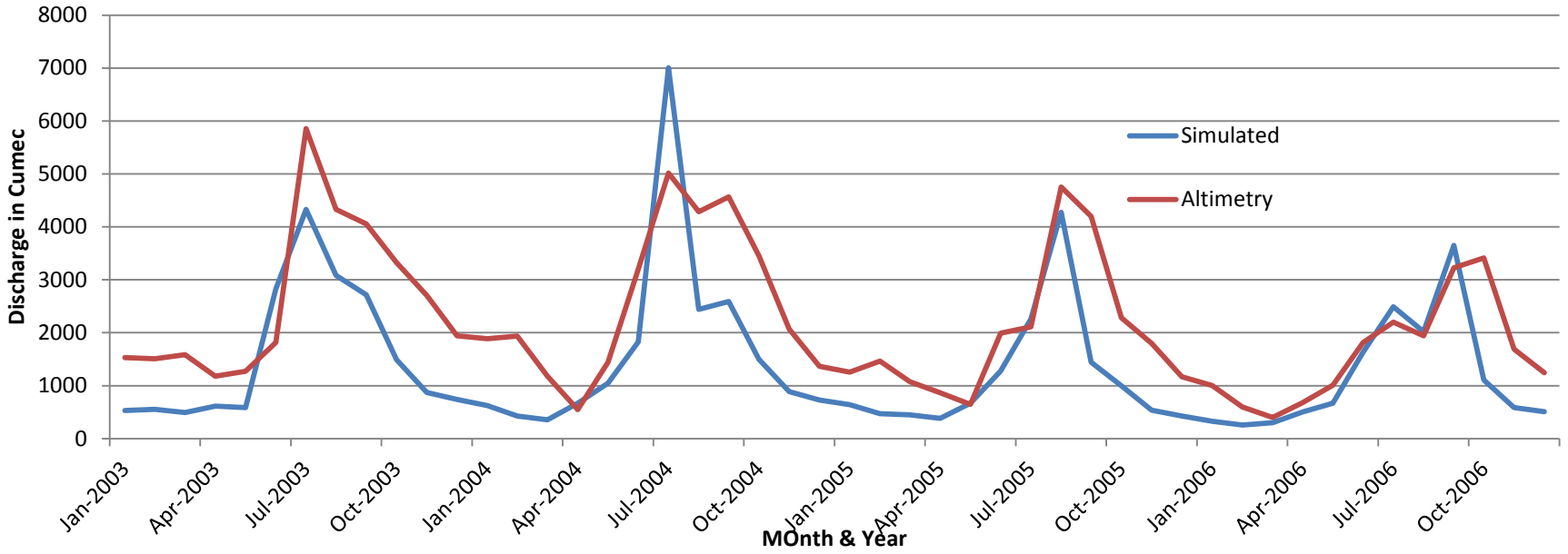
Lateral Flow Travel Time = 0 days				
Slp Lenth in m\Gw Delay in days	60	100	120	150
0	0.837	0.817	0.8069	0.79459
50	**0.886**	0.863	0.8513	0.8359
100	0.886	0.861	0.8483	0.83204
150	0.885	0.858	0.8447	0.82771

Lateral Flow Travel Time = 15 days				
Slp Lenth in m\Gw Delay in days	60	100	120	150
0	0.871	0.8564	0.84904	0.839406
50	**0.8865**	0.8633	0.85171	0.836224
100	0.8865	0.86	0.84734	0.830419
150	0.8861	0.8582	0.84502	0.827512

Lateral Flow Travel Time = 30 days				
Slp Lenth in m\Gw Delay in days	60	100	120	150
0	0.887	0.8756	0.86993	0.862309
50	**0.889**	0.8662	0.85559	0.841415
100	0.887	0.861	0.84883	0.832746
150	0.886	0.8588	0.8459	0.828878

Best parameter : Lateral Flow Travel Time – 30 days, Slope Length – 50, Groundwater Delay – 60 days

Model Performance for Monthly Water Yield variation: KOSI River Basin



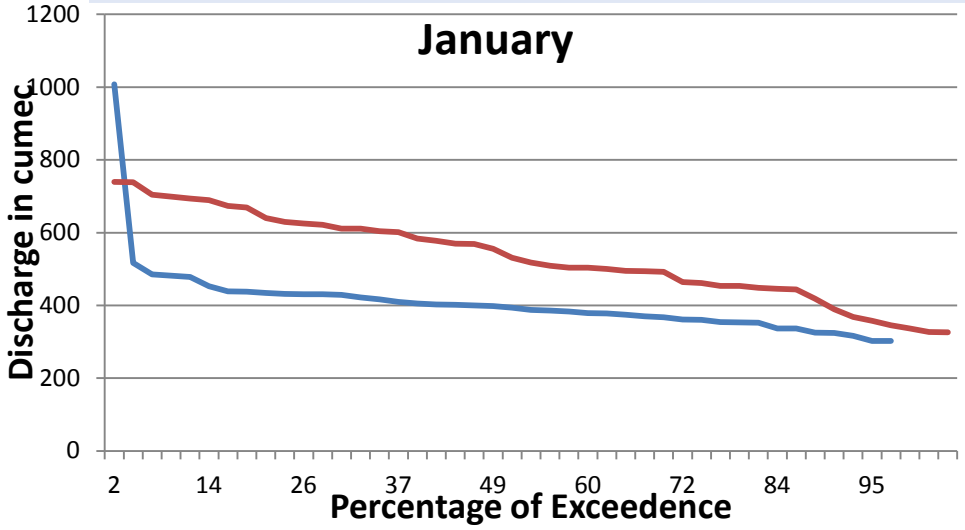
Findings

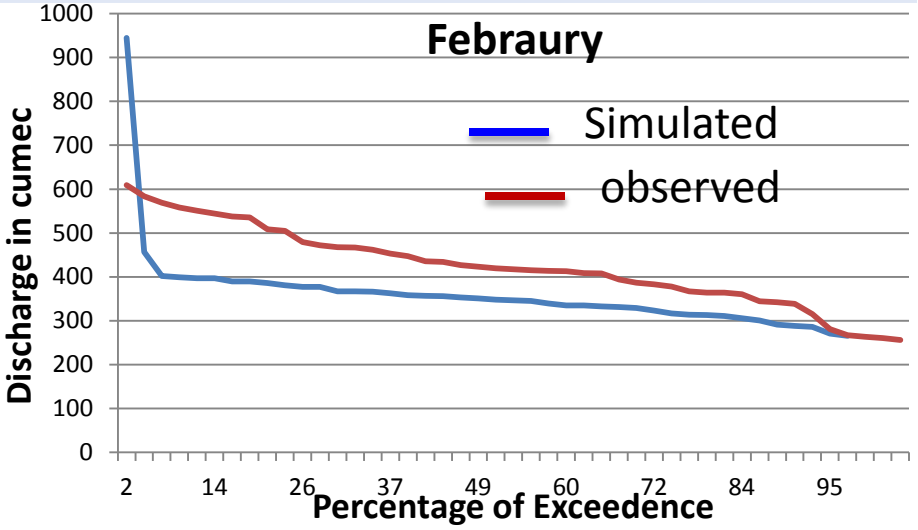
Flow prediction during monsoon onset months : satisfactory

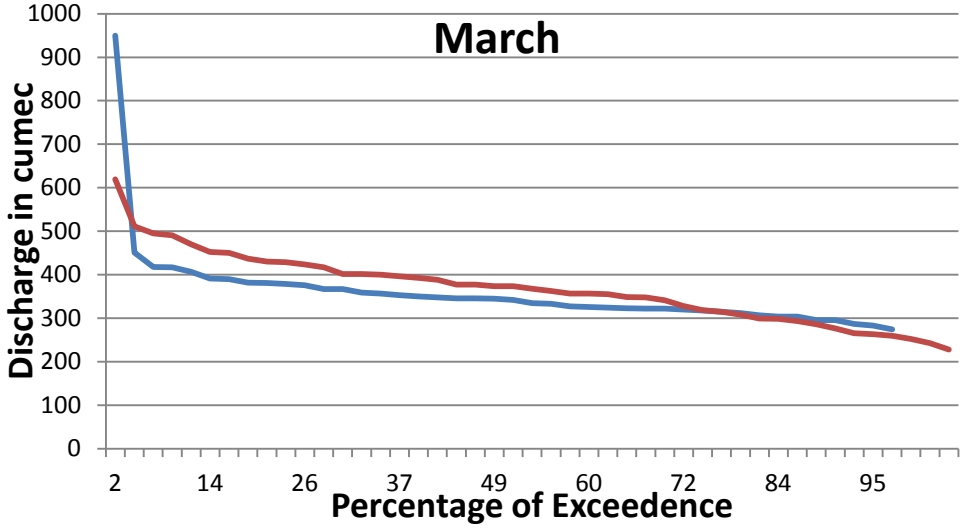
Flow prediction between August – October : not satisfactory (under-prediction)

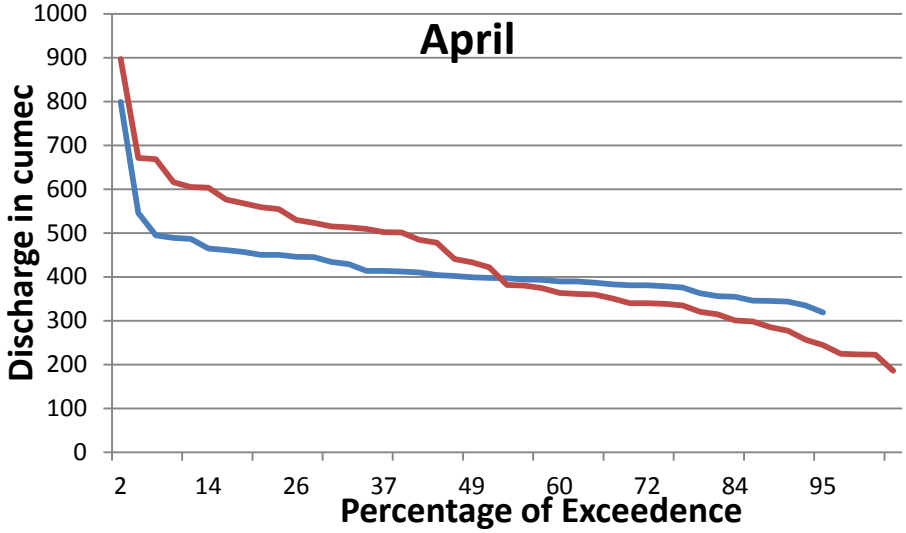
Lean Month Flow prediction : Satisfactory

Flow Duration Curve analysis for low flow prediction in KOSI River Basin (1961-1992)



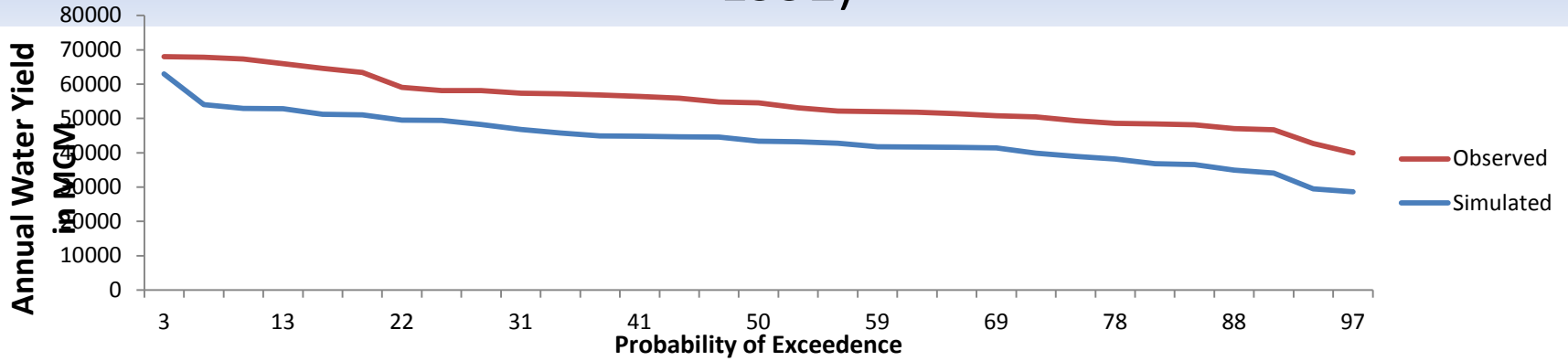


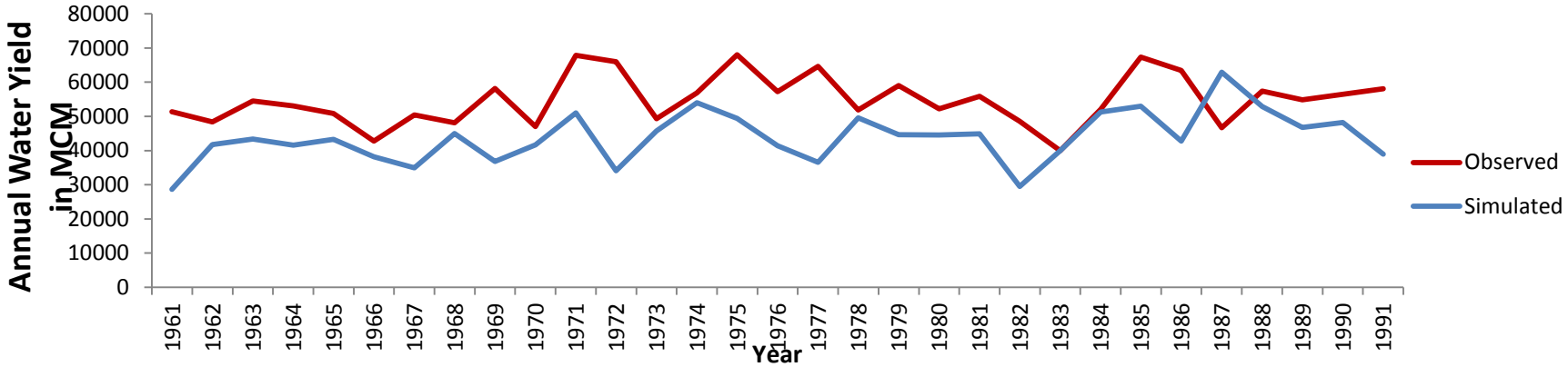


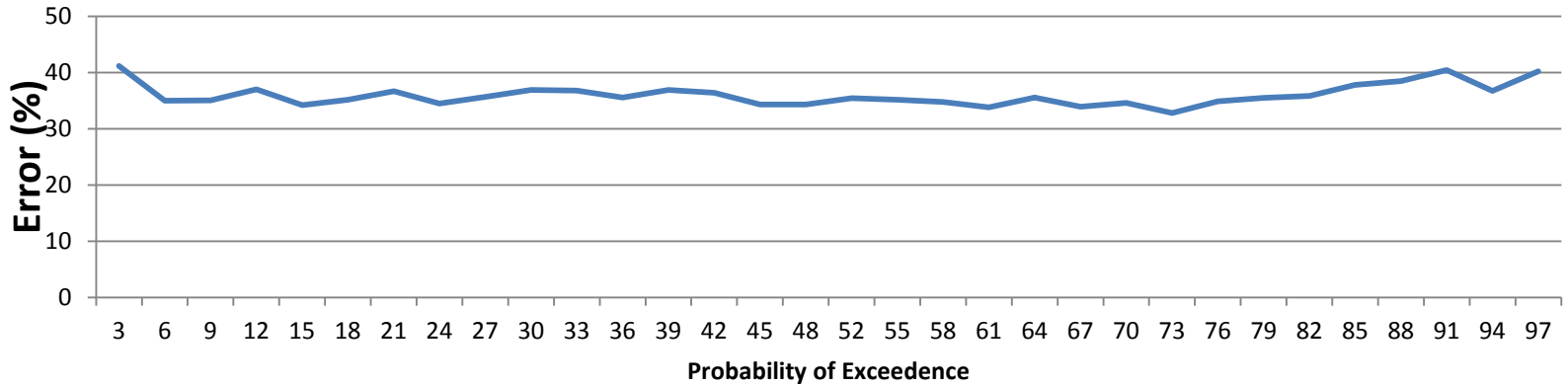


Findings : under prediction in January and February, satisfactory in March and April Months

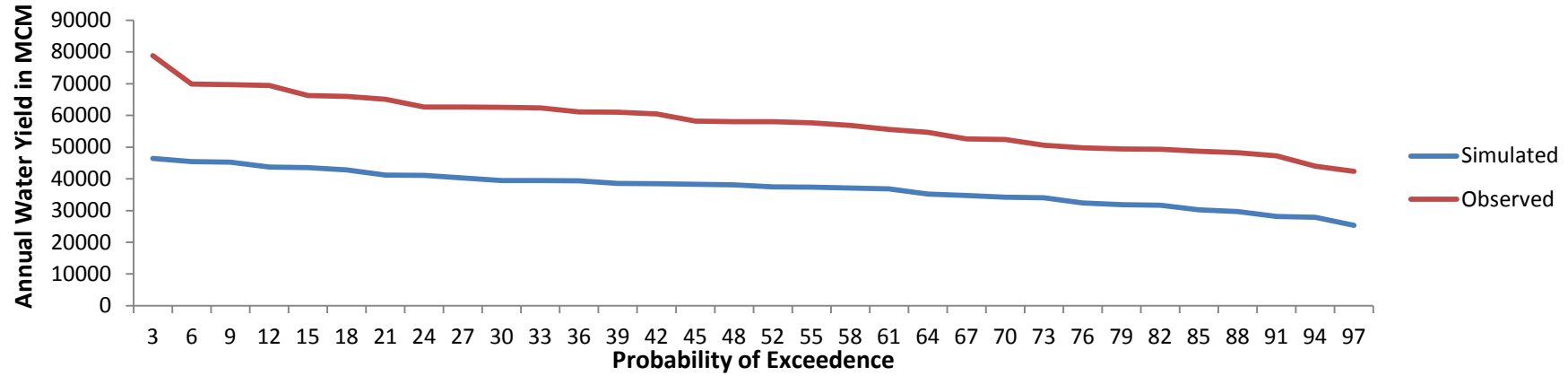
Model Performance for Annual Water Yield: KOSI River Basin(1961-1992)

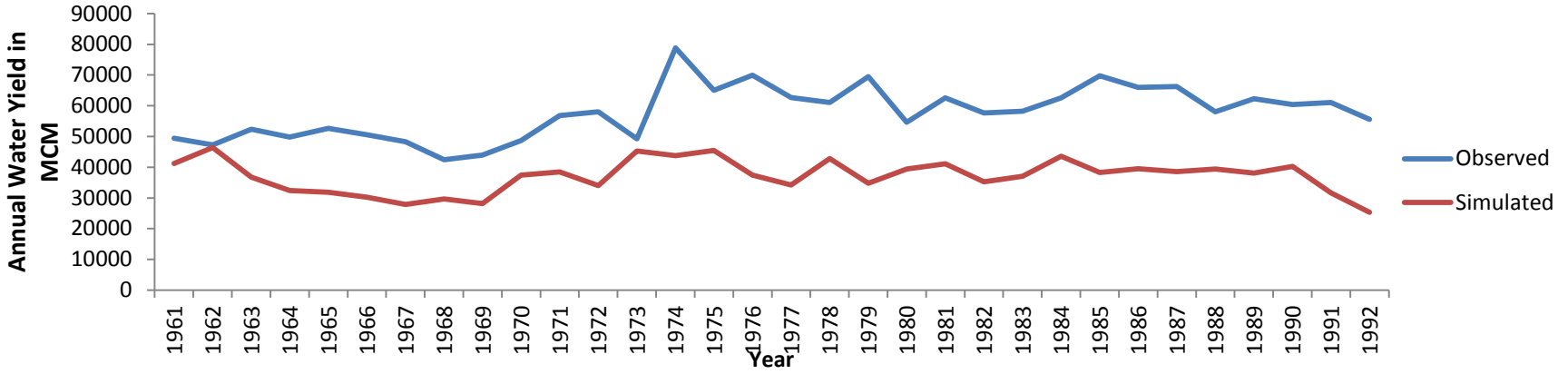


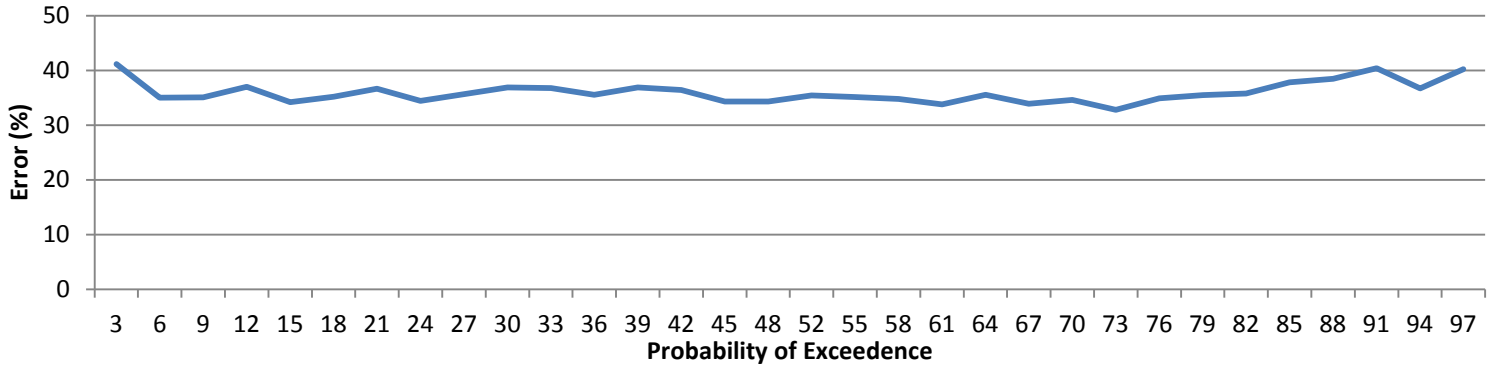




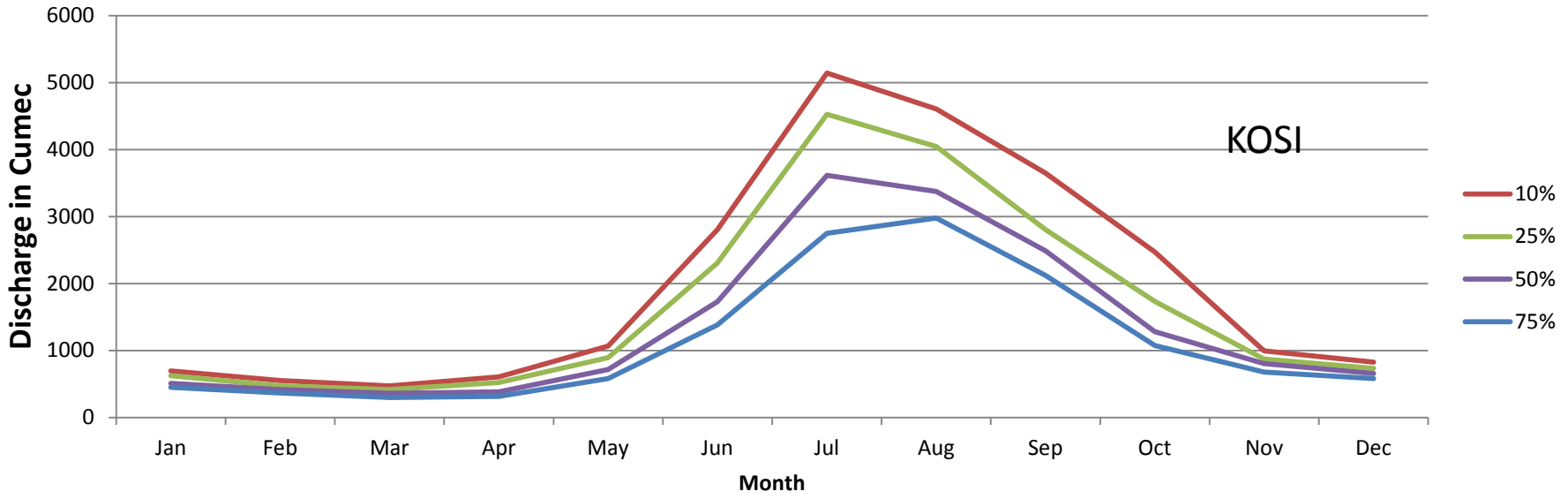
Model Performance for Annual Water Yield: GANDAK River Basin

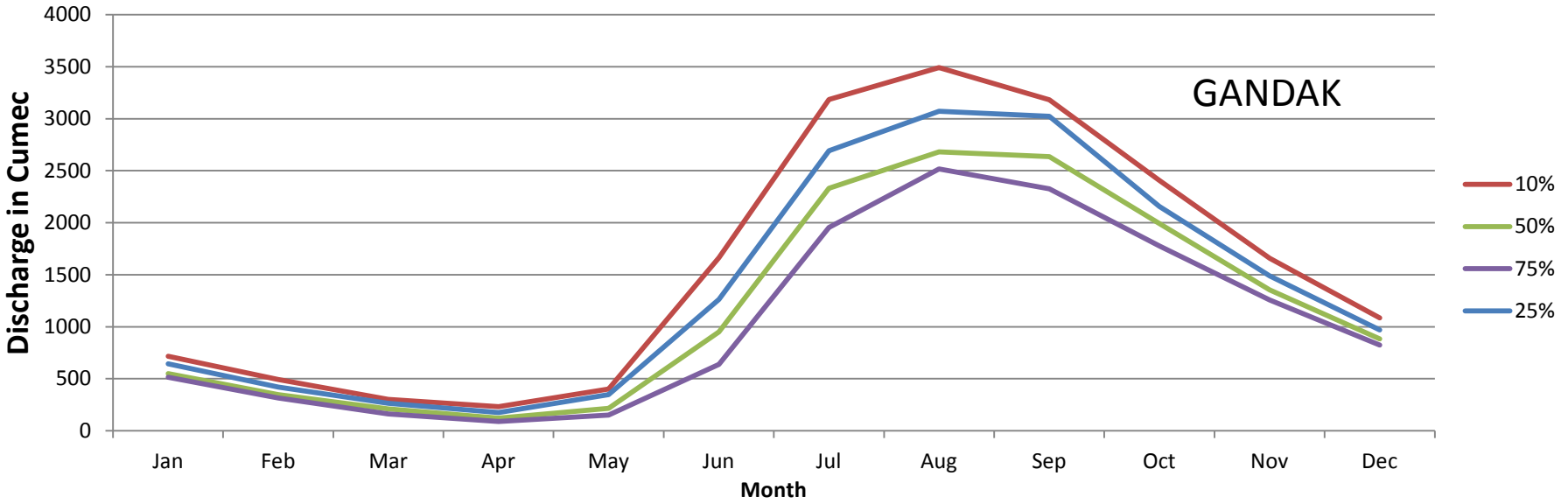






Monthly Variation of Dependable Flow





Conclusions and discussion

- For annual water yield, the mode predication is under-predication with 20-30% deviation. It may be attributed to error in gridded rainfall in the Himalayan region during August to October

- Low Month flow prediction: lumped calibration parameters (ground water) are used. The sub-basin variation of these parameters will be considered.

- More detailed calibration required. For basin management plan, what if conditions need to be simulated and possible change in water availability and quantity can be assessed using the model.


Thank you